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Image Identification-Classification Method Integrated Multi-Feature by Adaboost Algorithm

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Abstract

An image identification and classification method based on multi-feature integration is proposed in this paper. The images' colour, shape, texture features are integrated by Adaboost algorithm for image identification and classification. Meanwhile, the weak classifiers are integrated to form a strong classifier. The experimental result shows that the proposed approach has a good identification and classification performance.

Keywords

Image Identification; Image Classification; Adaboost Algorithm; Multi-Feature Integration; Algorithm Integration

Introduction

With the explosive growth of the number of images, it's much more difficult to find the wanted picture. The traditional methods of classifying the images have many problems, such as the keyword search by manual annotating the images and the CBIR (Content Based Image Retrieval) method. The first method may cost a lot of manpower and financial resources, and the second method also has many unresolved problems. The image identification and classification technique based on images' features appears to solve these emerging problems. It can automatically classify the images to the corresponding class according to the images' features, and it also can greatly reduce the workload of manual annotation and improve the retrieval accuracy.

There are many features of an image, such as colour, texture, shape, spatial relations, and edge relations. One feature only reveals one-sided image and different features have different classification results, so we can combine these features to describe images. In this paper, an image identification and classification method integrated multi-feature by Adaboost algorithm is presented.

Extraction of Colour, Texture and Shape

The Extraction of Image'S Colour

The traditional RGB (Red(R), Green (G),Blue(B)) model is suitable for display system, not suitable for image analysis. The HSV (Hue (H), Saturation(S), and Value (V)) colour space is relatively closedto the human eye's colour perception space. So in this paper, The HSV model is used to extract the colour feature.

The extraction steps are as follows:

- Quantize the HSV space to unequal interval:

  Turn the RGB space into HSV space and quantize the HSV space to unequal interval. Hue component is quantized into 16 levels; Saturation component is quantized into 4 levels; Value component is quantized to 4 levels.

- Combine the three colour components into a one-dimensional feature vector:

$$L = H*Qs*Qv+S*Qv+V \tag{1}$$

  where $Qs=4$, $Qv=4$.

- Calculate the L histogram.

The Extraction of Image'S Texture

GLCM (Gray-Level Co-Occurrence Matrix) method is proposed by Haralick in 1973. It is built on the estimation of image's second-order conditional probability density function. GLCM describes the occurrence probability of two pixels whose values are i and j, in the θ direction and d pixels distance. The probability is written as $P(i, j, d, \theta)$.

The extraction steps are as follows:

- Calculate the co-occurrence matrix. $P(i, j, d, \theta)$ is calculated by the following formula:

$$P(i, j, d, \theta) = \{[(x, y), (x+\Delta x, y+\Delta y \mid f(x, y) = i, \\ f(x+\Delta x, y+\Delta y) = j)]\} \quad (2)$$

- Convert the colour images to greyscale images.

$$gray = 0.3 \times R + 0.59 \times G + 0.11 \times B \quad (3)$$

Gray is the gray value (Gradation is quantized to 256 levels); R, G, B are the red, green and blue components.

- Reduce the matrix dimensions. In order to reduce the amount of calculation and improve the speed of feature extraction, the matrix is reduced to 16 dimensions.
- Calculate the texture parameters. Calculate the energy, entropy, moment of inertia, relation of the four co-occurrence matrixes. Finally, use the mean and standard deviation of the four parameters as the components of the texture feature vector.

The Extraction of Image'S Shape

Geometric momentincluding translation, rotation and scale invariance, so it is also called invariant moment. In image processing, geometric moment invariants can be used as an important feature to represent the object. It can be classified according to this feature of the image.

The extraction steps are as follows:

- **Convert the color images to greyscale images, and then turn it into binary.**
- **Calculate the image's normalized central moment:**

The image area $f(x, y)$ is piecewise continuous, its $(m+n)$ order geometric moments in Cartesian system is:

$$M_{mn} = \iint_D x^m y^n f(x, y) dxdy \quad (4)$$

$(m+n)$ order central moments is defined as:

$$u_{mn} = \iint_D (x-x_0)^m (y-y_0)^n f(x, y) dxdy \quad (5)$$

x_0, y_0 represent the image's focus. Because the image is discrete, we can use sum instead of integral. The formula is as follows:

$$u_{mn} = \sum_{i=1}^{M} \sum_{j=1}^{N} f(i, j)(i-i_0)^m (j-j_0)^n \quad (6)$$

where $(i_0, j_0) = (M_{10} / M_{00}, M_{01} / M_{00})$.

The normalized central moment is: $I_{mn} = u_{mn} / M_{00}^{\frac{m+n+2}{2}}$. It not only has translation invariance, but also has scale invariance.

- Calculate the seven invariant moments of an image. The formulas are as follows:

$$\left.\begin{aligned}
&C_1 = I_{20} + I_{02}\\
&C_2 = (I_{20} - I_{02})^2 + 4I_{11}^2\\
&C_3 = (I_{30} - 3I_{12})^2 + (3I_{21} - I_{03})^2\\
&C_4 = (I_{30} + I_{12})^2 + (I_{21} + I_{03})^2\\
&C_5 = (I_{30} - 3I_{12})(I_{30} + I_{12})[(I_{30} + I_{12})^2 - 3(I_{21} + I_{03})^2]\\
&\qquad + (3I_{21} - I_{03})(I_{21} + I_{03})[3(I_{30} + I_{12})^2 - (I_{21} + I_{03})^2]\\
&C_6 = (I_{20} - I_{02})[(I_{30} + I_{12})^2 - (I_{21} + I_{03})^2]\\
&\qquad + 4I_{11}(I_{30} + I_{12})(I_{21} + I_{03})\\
&C_7 = (3I_{21} - I_{03})(I_{30} + I_{12})[(I_{30} + I_{12})^2 - 3(I_{21} + I_{03})^2]\\
&\qquad - (I_{30} - 3I_{12})(I_{21} + I_{03})[3(I_{03} + I_{12})^2 - (I_{21} + I_{03})^2]
\end{aligned}\right\} \tag{7}$$

Adaboost Algorithm

Colour, texture and shape features that we extracted have different classification results between different categories. So we should normalize each feature and weigh them to get the training and testing samples.

Adaboost is an iterative algorithm. It's core idea is to trainweak classifiers with the same training set, and then put these weak classifiers together to construct a stronger final classifier. The algorithm is implemented with changing the data distribution. According to whether each sample is classified to the right category and the accuracy of the previous overall classification to determine the weights of each sample, the new sample data will be delivered to the underlying classifier for training. At last each weak classifier is integrated to be the final decision-classifier.

In this paper, we use Adaboost algorithm that integrated with weak classifiers of single characteristic for the strong classifier.

$$\mathrm{h}_j(x) = \begin{cases} 1 & if\ p_j f_j(x) < p_j\theta_j \\ 0 & otherwise \end{cases} \tag{8}$$

The steps are as follows:

- n training samples $\{x_1, y_1\},...,\{x_n, y_n\}$,and $y_i = \{0,1\}$ is the categories' label.
- Initialize error weights according to the follow formula :

$$w_{t,i} = \begin{cases} \dfrac{1}{m} & y_i = 0 \\ \dfrac{1}{n} & y_i = 1 \end{cases} \tag{9}$$

$w_{t,i}$ is the error weight of sample i in t cycle.

- For $t = 1,...,T$:

Normalize the weights according to formula (10):

$$w_{t,i} = \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,i}} \tag{10}$$

where j represents each feature. Train a classifier h_j with one feature. Determine the threshold θ_j and the bias p_j to make $\varepsilon_j = \sum_i \left| h_j(x_i) - y_j \right|$ to minimum. h_t is the simple classifier with minimum ε_j . Add h_t to the strong classifier and then update all samples' weights $w_{t+1,i} = w_{t,i}\beta_t^{1-e_i}$, $\beta_t = \varepsilon_t / (1-\varepsilon_t)$, $e_i = 0$ if x_i is classified to the right category, else $e_i = 1$.

- The final strong classifier is:

$$h(x)=\begin{cases}1 & \sum_{t=1}^{T} a_t h_t \geq 0.5\sum_{t=1}^{T}\alpha_t \\ 0 & otherwise\end{cases} \qquad \alpha_t=\log\frac{1}{\beta_t} \tag{11}$$

Experiments and Result Analysis

The experiment images are from Corel standard image library. A total of 400 images,4 categories,100 pieces of each category. They are buses, dinosaurs, elephants and flowers. The iteration is from 5 to 50 and the result is as Fig.1.

The x axis represents the iteration times, and the y axis represents the recognition rate. The four lines in this figure represent four kinds of sample types.

According to Fig.1, we can see that single feature's classification effect is not very desirable, but the accuracy of the three integrated features can reach to more than 98 percent. So this method is better than the original one.

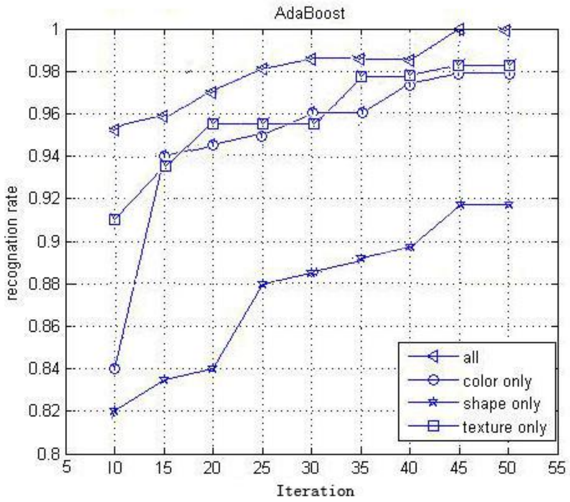

Fig. 1 THE RESULT OF EXPERIMENT.

Conclusion

A single feature can express part properties of the image which lead to the problem of low classification accuracy. In this paper, an image identification and classification method is proposed based on colour, texture and shape features integration, and we use the Adaboost algorithm to improve the accuracy of classification. The result shows that the proposed method has better identification and classification results.

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